

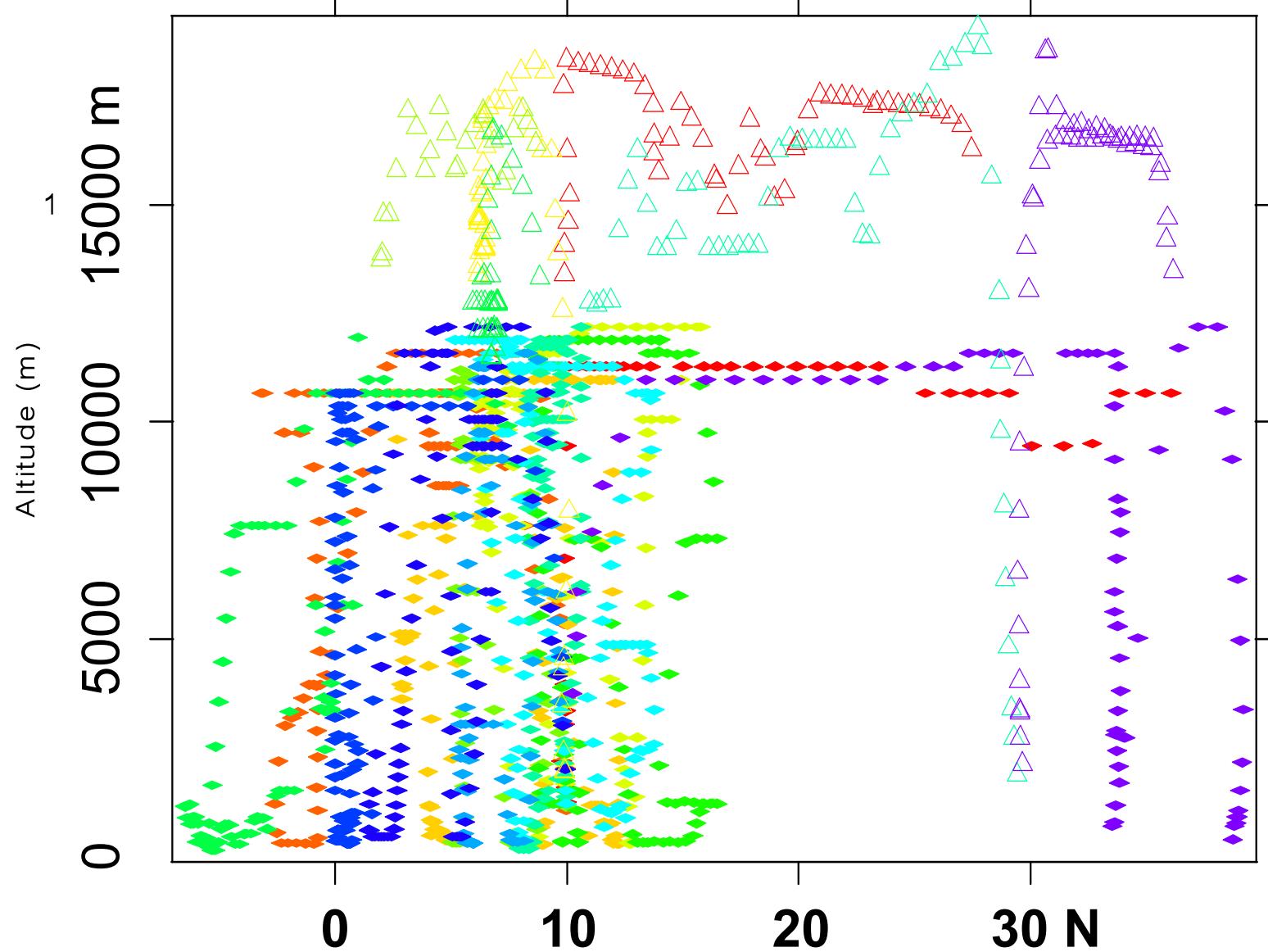
Tracers in ATTREX: What we learn from CR-AVE, TC-4, and HIPPO

Steve Wofsy

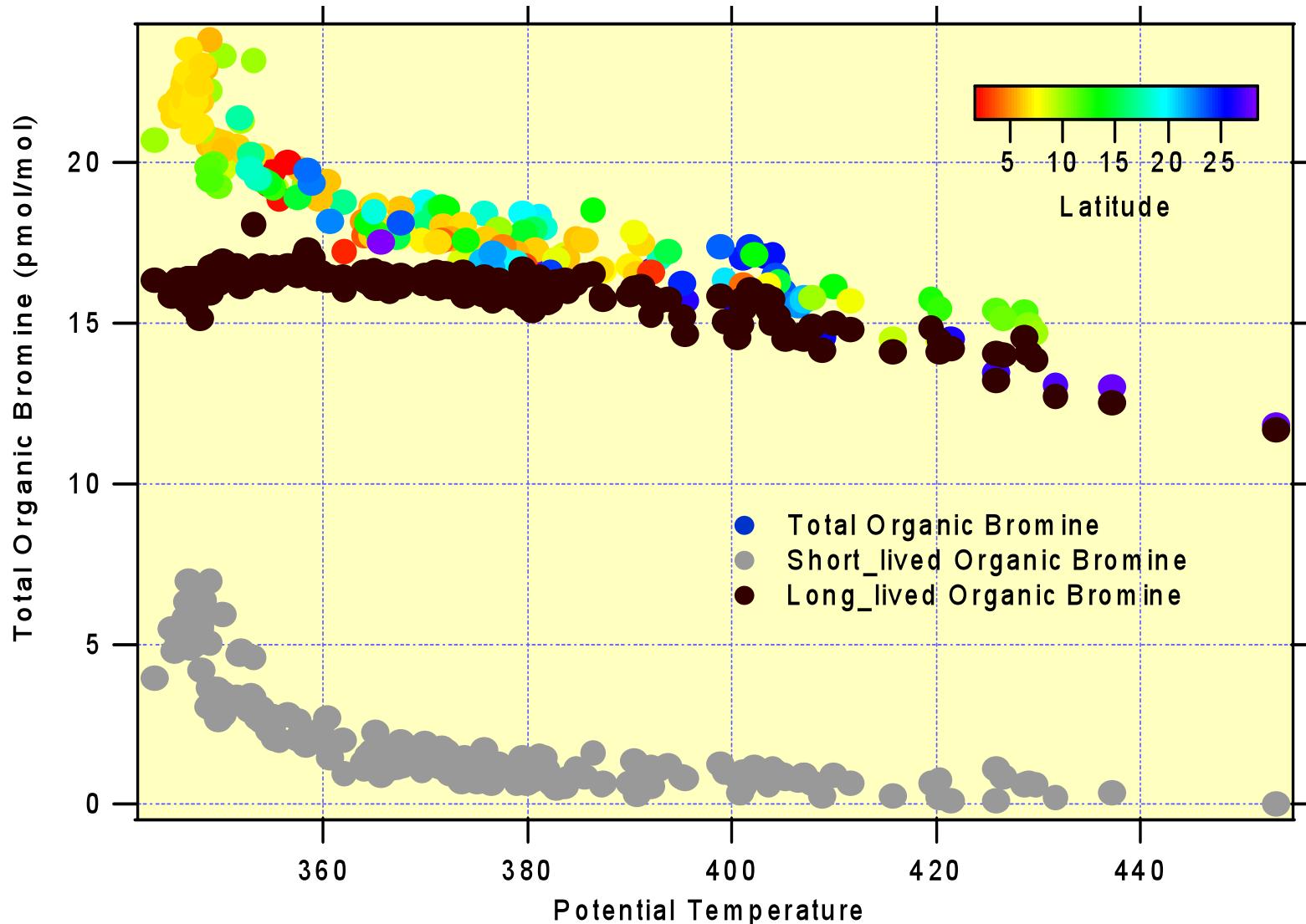
Elliot Atlas

*Presented at the ATTREX Science Team
meeting, DFRC 26 Aug 2010*

Whole Air Sample Locations during TC4: DC8 and WB-57



Variation of total organic bromine in the TTL during TC4



What we learn from this:

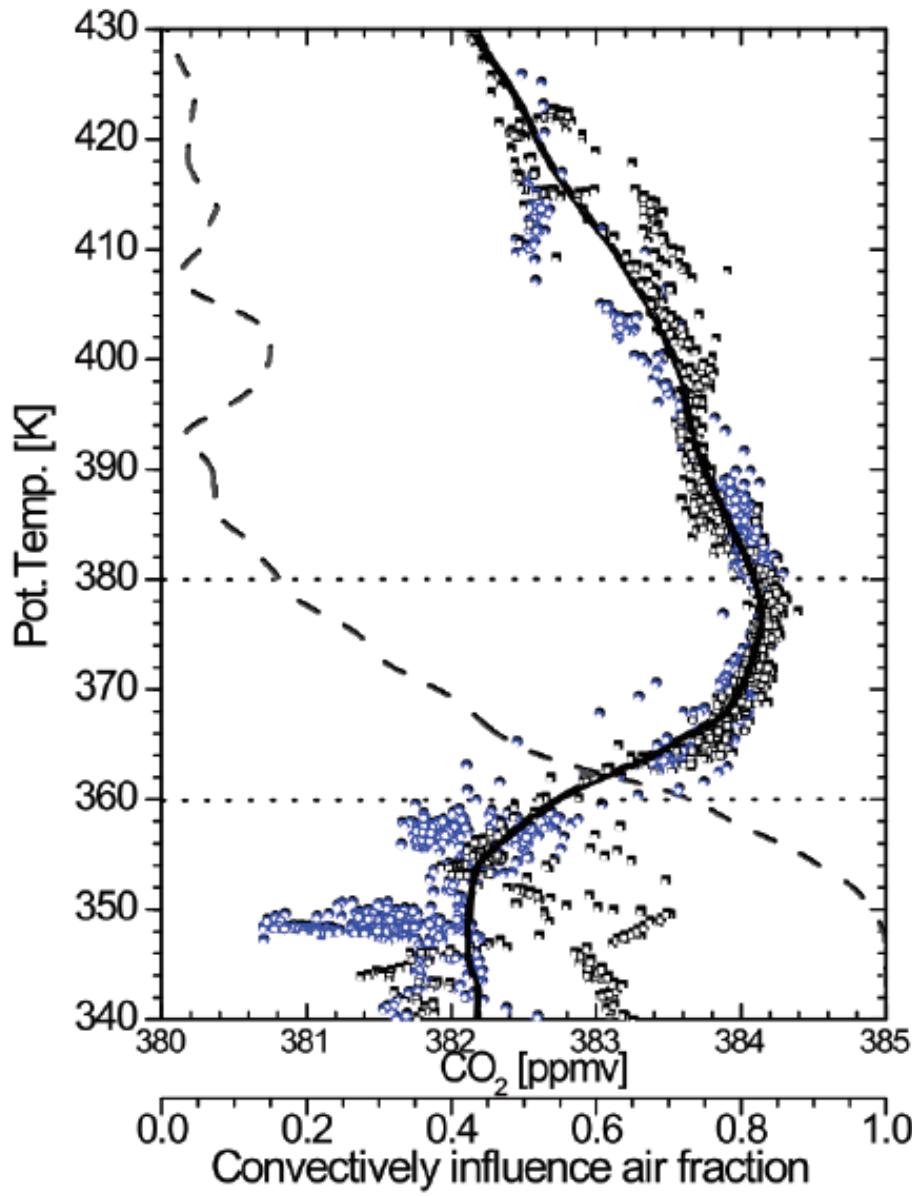
Short lived organic bromine compounds add about 2 ppt of Br to the lower tropical troposphere in one region & season

What we have yet to learn:

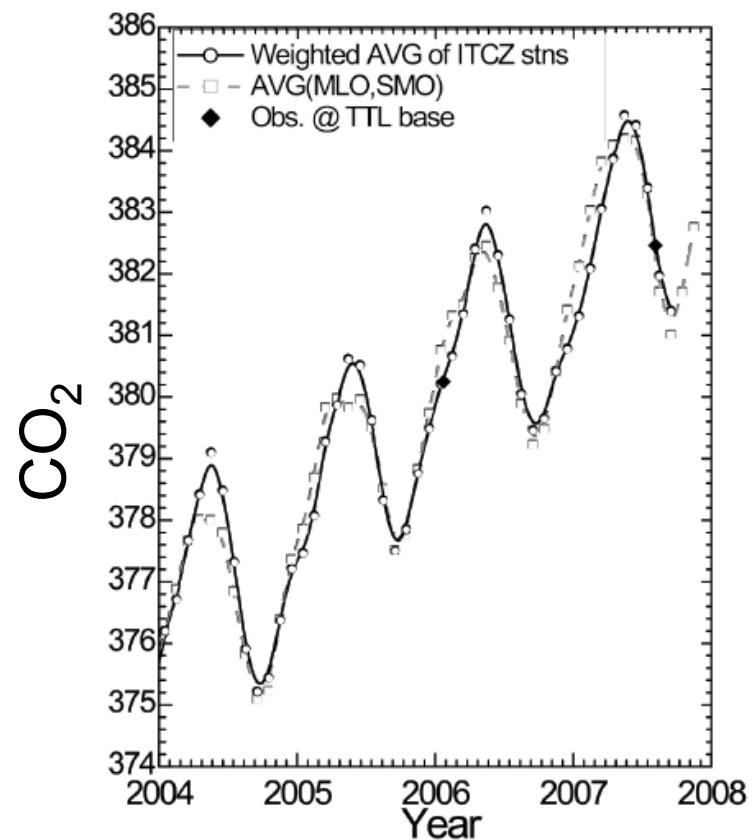
What is the global picture ?

Is inorganic Br left behind or scavenged ?

"upper TTL"



CO₂ in TC-4 –
seasonal cycle and
long-term trend
provide a unique
probe of transport
rates and processes.



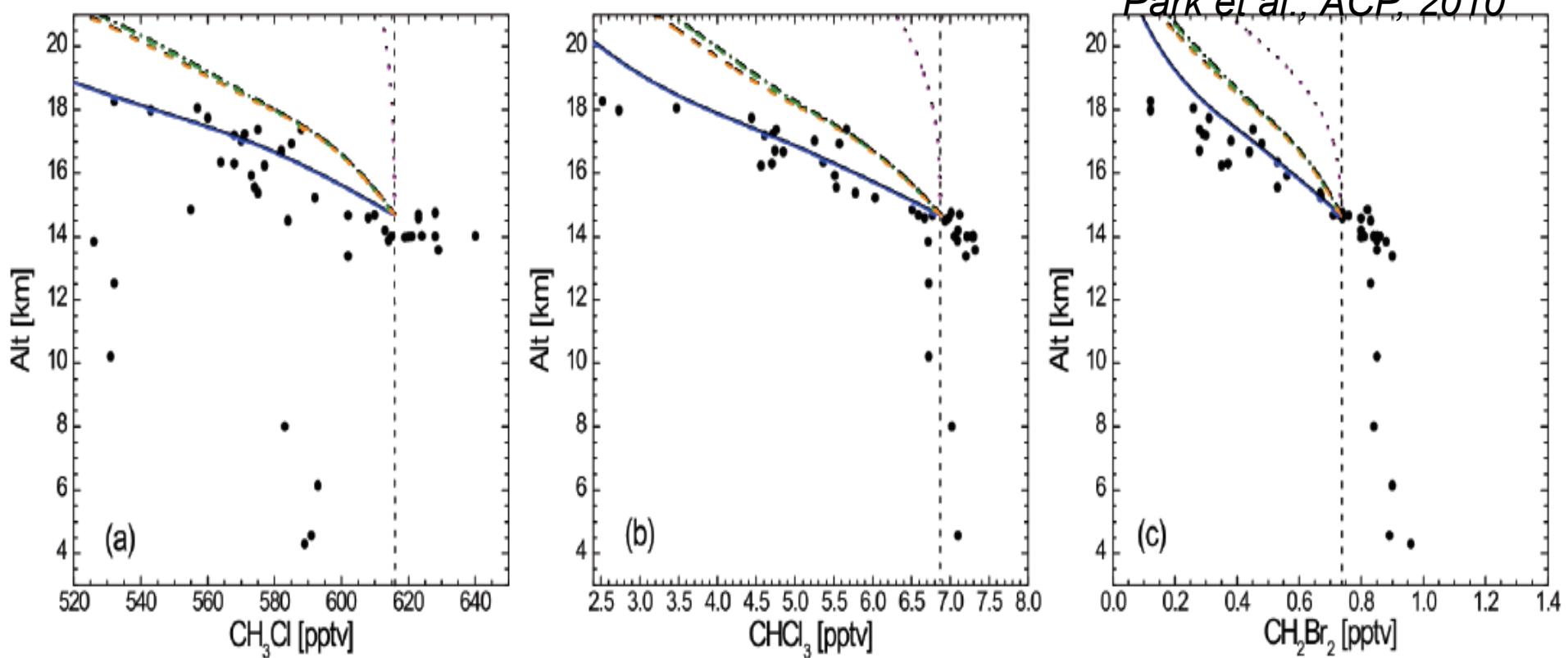
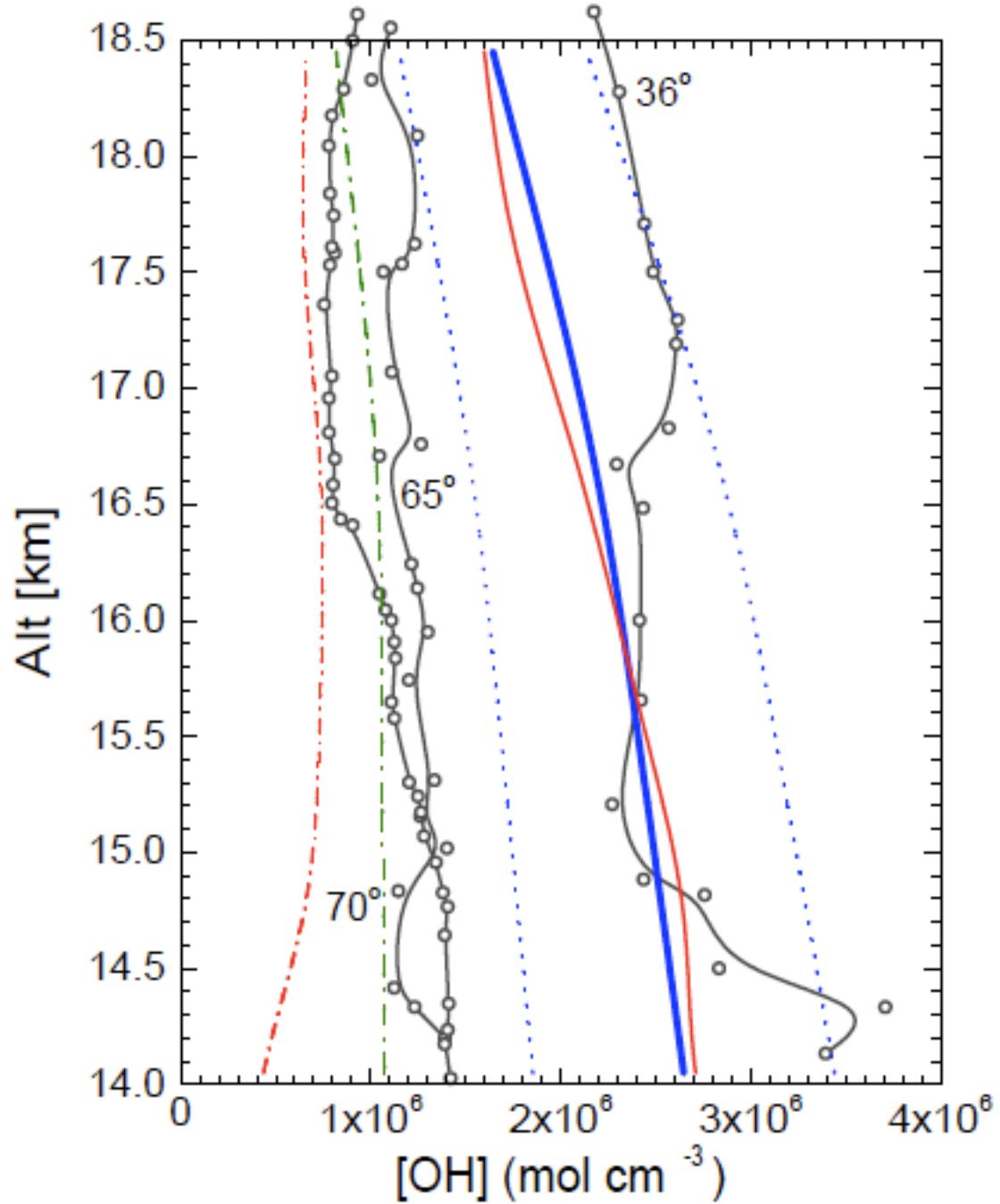


Figure 5. Vertical distributions of (a) CH_3Cl , (b) CHCl_3 , and (c) CH_2Br_2 . Shown are the simulated profiles of 1-D model using combined inputs of photolysis and reaction with OH radicals.

The equation for our 1-D column model describes mass continuity of the mole fraction c in a column,

$$\frac{\partial c}{\partial t}N - \frac{\partial}{\partial z}K_z N \frac{\partial c}{\partial z} + wN \frac{\partial c}{\partial z} + Naf \frac{c - c_0}{\tau_{\text{conv}}} = P - L$$

I II III IV V



Optimum 24-hr mean
OH profiles

GMI

GEOS-CHEM

(dashed lines give a
priori model OH)

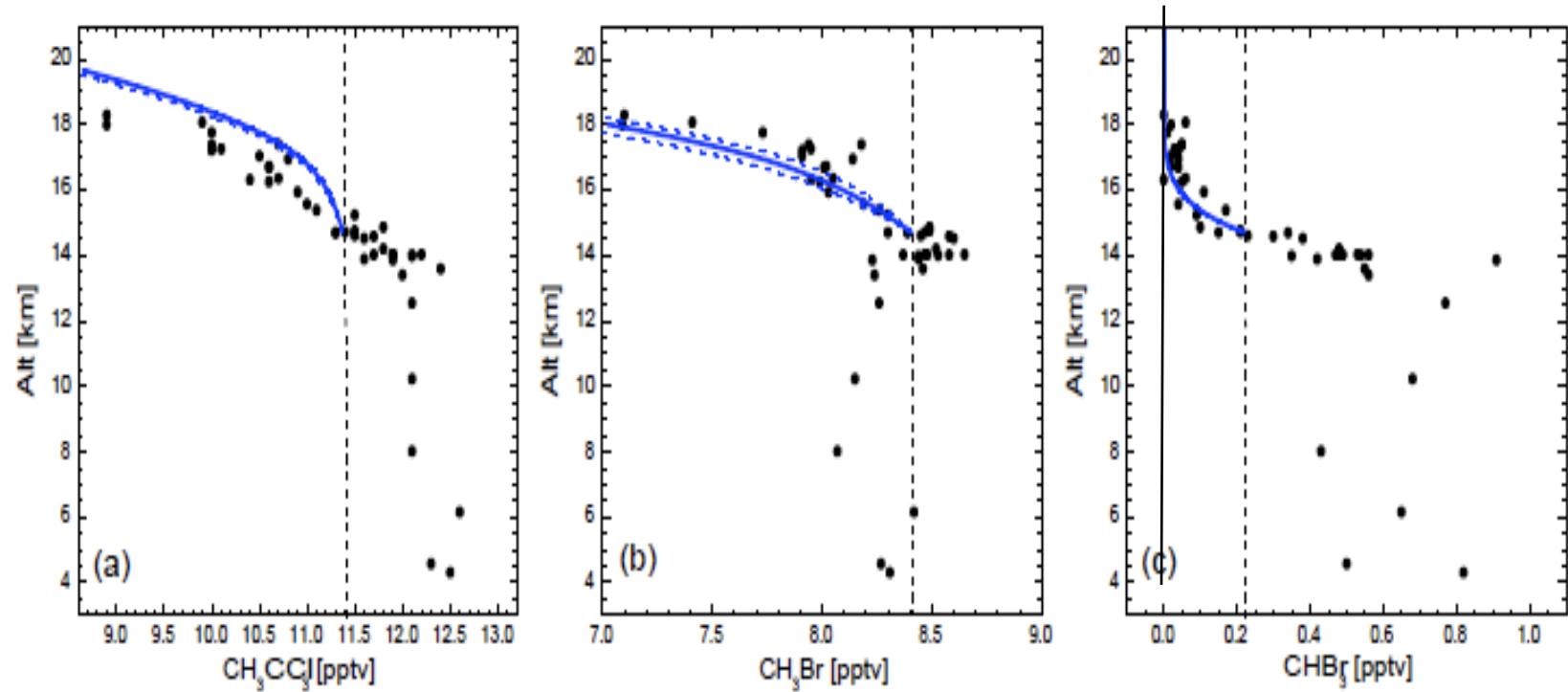
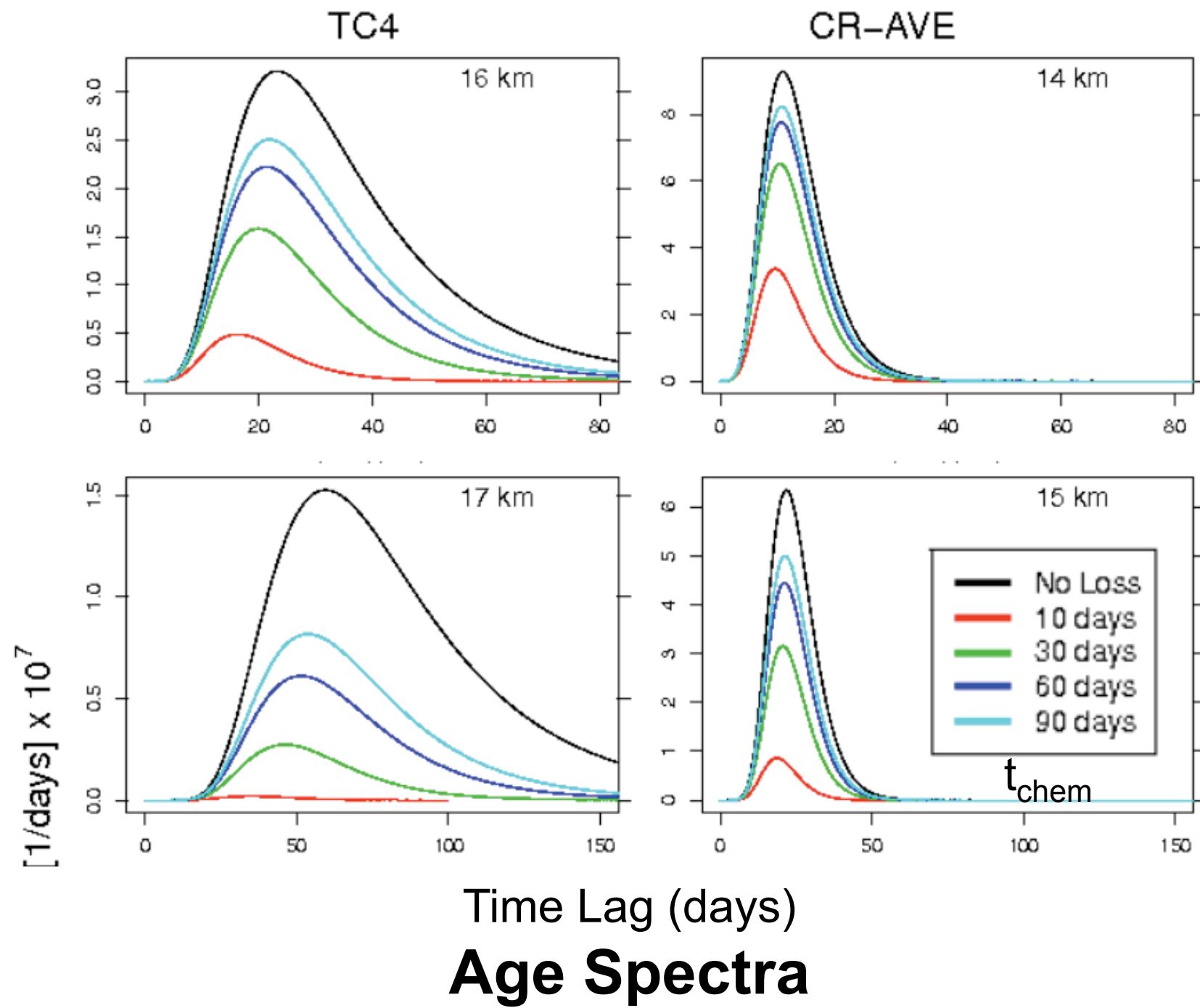
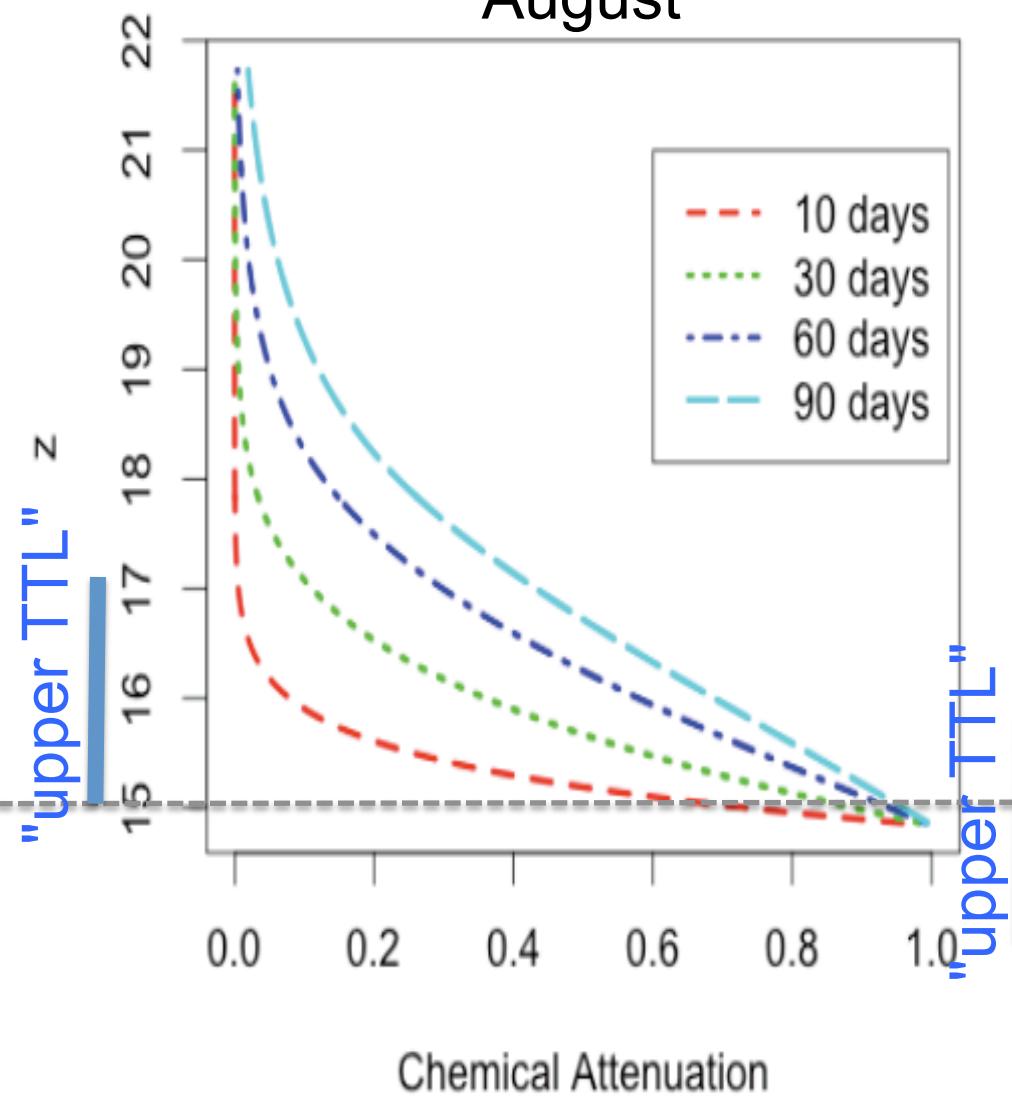


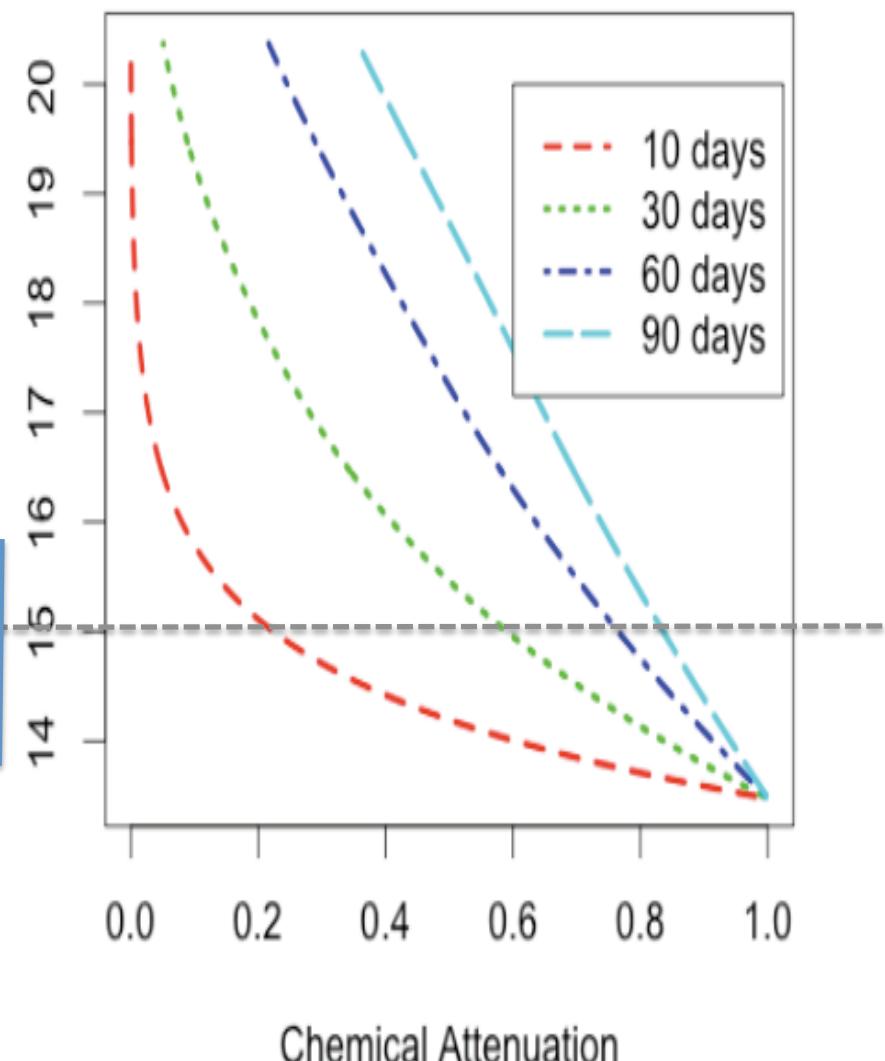
Fig. 7. Vertical distributions of (a) CH_3CCl_3 , (b) CH_3Br , and (c) CHBr_3 . Symbols are the same as in Fig. 5. The blue dotted lines denote the fits with $\pm 30\%$ uncertainties in [OH].



TC4
August

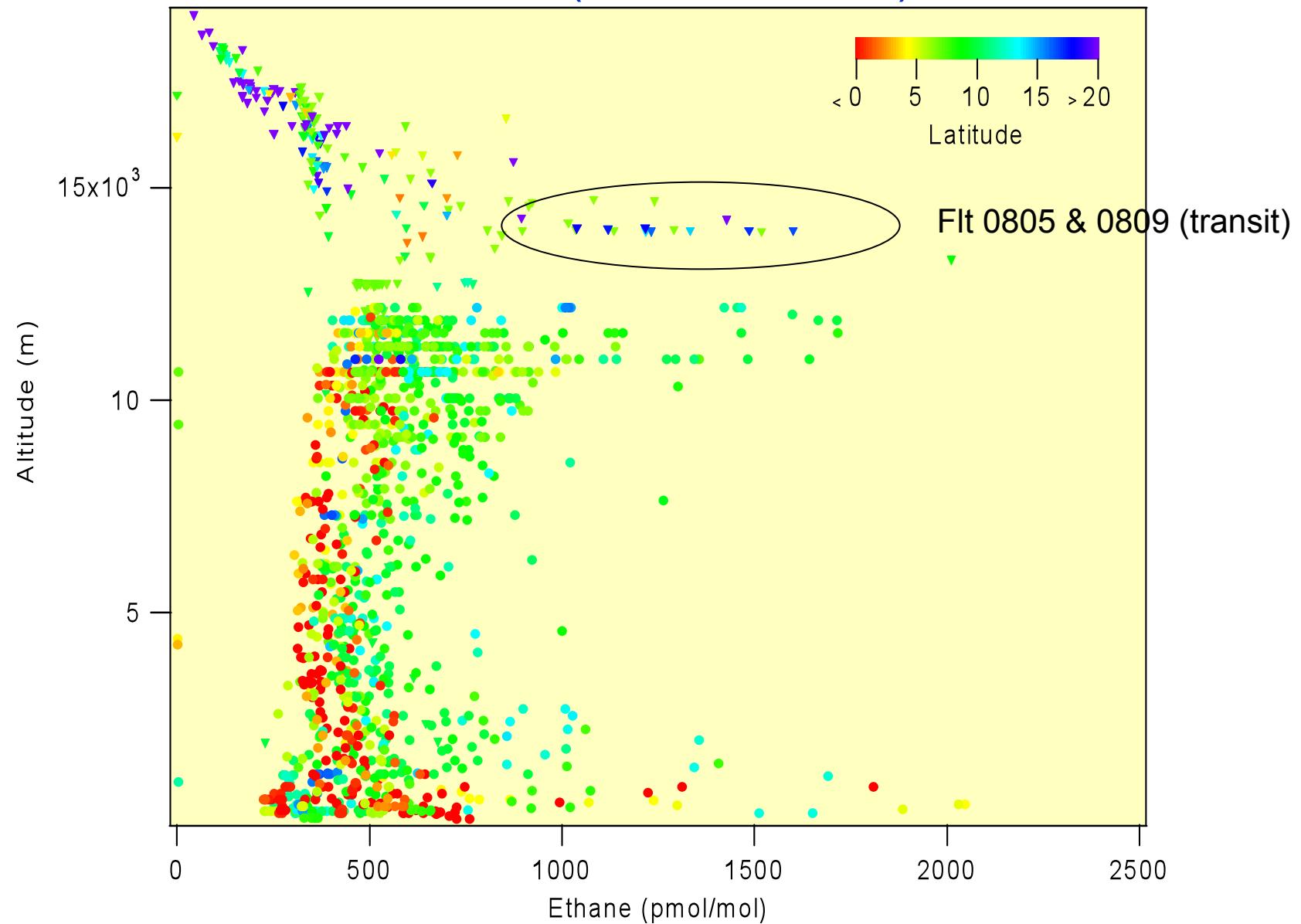


February
CR-AVE



Source signatures in the UT: Hydrocarbons

Ethane (continental BL)



What we learn from this:

CO_2 data can resolve transport time scales of a few days in most seasons, relative to zero age in the ICTZ.

CO_2 and data for short lived tracers, with diverse loss mechanisms, can tell us quantitatively about loss rates and transport rates for radical precursors in the TTL.

What we have yet to learn:

What is the global picture ?

How can we do much better than the 1-d (!!) model.

HIPPO: What do the GV cross sections of the Pacific tell us about what we will see from the Global Hawk in ATTREX?

HIPPO and ATTREX share a key characteristic: each is taking a broad swath of atmospheric data which will simultaneously give fine-grained texture and a global image.

Unexpected results are very likely to emerge.

Brooks Range, AK

NCAR Gulfstream V "HIAPER"



GV launch in the rain, Anchorage, January, 2009 (HIPPO-1)

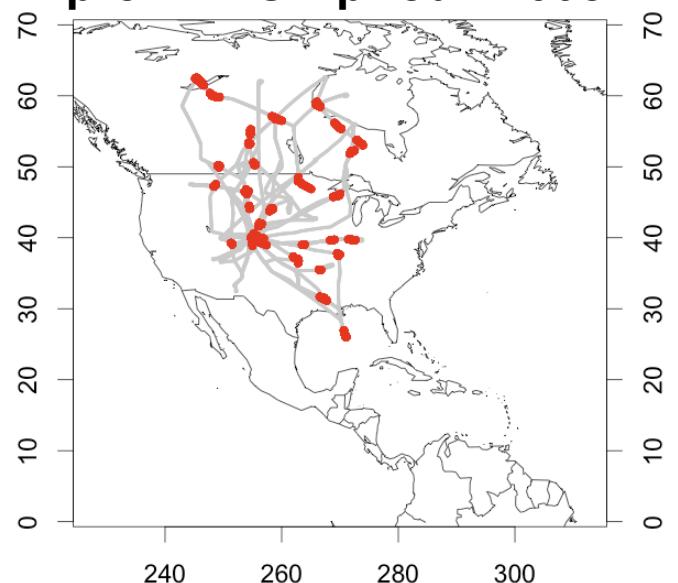
HIPPO Instrumentation

Harvard/Aerodyne—HAIS QCLS	CO_2 , CH_4 , CO , N_2O (1 Hz)
NCAR A02	O_2/N_2 , CO_2 (1 Hz)
Harvard OMS CO_2	CO_2 (1 Hz)
NOAA CSD O_3	O_3 (1 Hz)
NOAA GMD O_3 , H_2O	O_3 , H_2O (1 Hz)
NCAR RAF CO	CO (1 Hz)
NOAA-GMD UCATS and PANTHER GCs	CO , CH_4 , N_2O , CFCs, HCFCs, SF_6 , CH_3Br , CH_3Cl , H_2 (70 – 200 s)
Whole Air Samples: NWAS (NOAA-GMD), AWAS (Miami), MEDUSA (NCAR/Scripps)	O_2/N_2 , N_2/Ar , CO_2 , CH_4 , CO , N_2O , SF_6 , H_2 , COS, CS ₂ , halocarbons, solvents, reactive HCs, marine species, ...
VCSEL Princeton/SWS	H_2O (1 Hz)
NOAA SP2	Black Carbon mass (1 Hz)
MTP, wing stores	T, P, winds, aerosols, cloud water

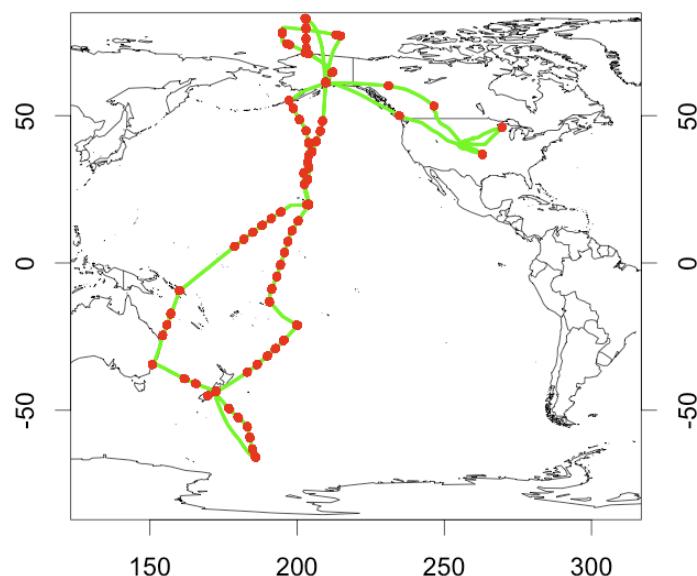
Multiple measurements: *Red symbols* ≥ 3 , *Blue* = 2;
sampling rates in ().

HIPPO itinerary

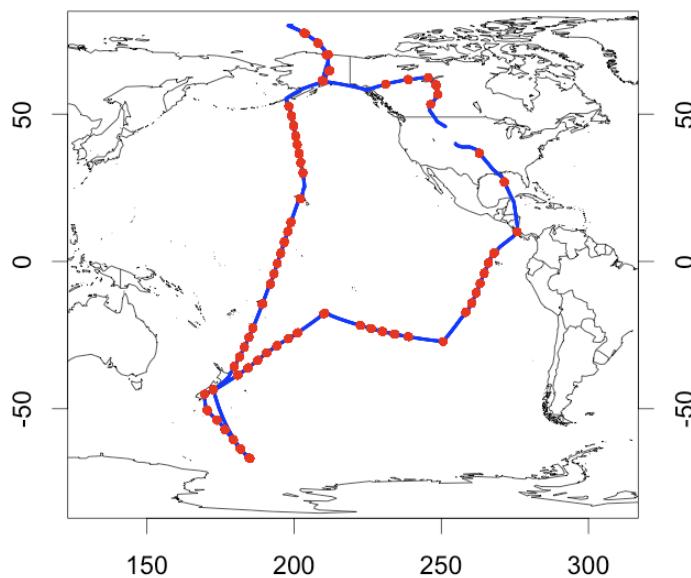
preHIPPO Apr-Jun 2008



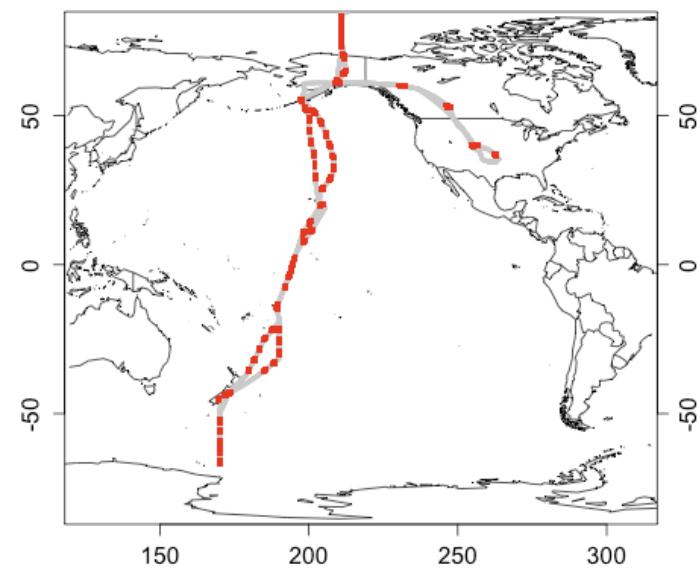
HIPPO_2 Nov 2009



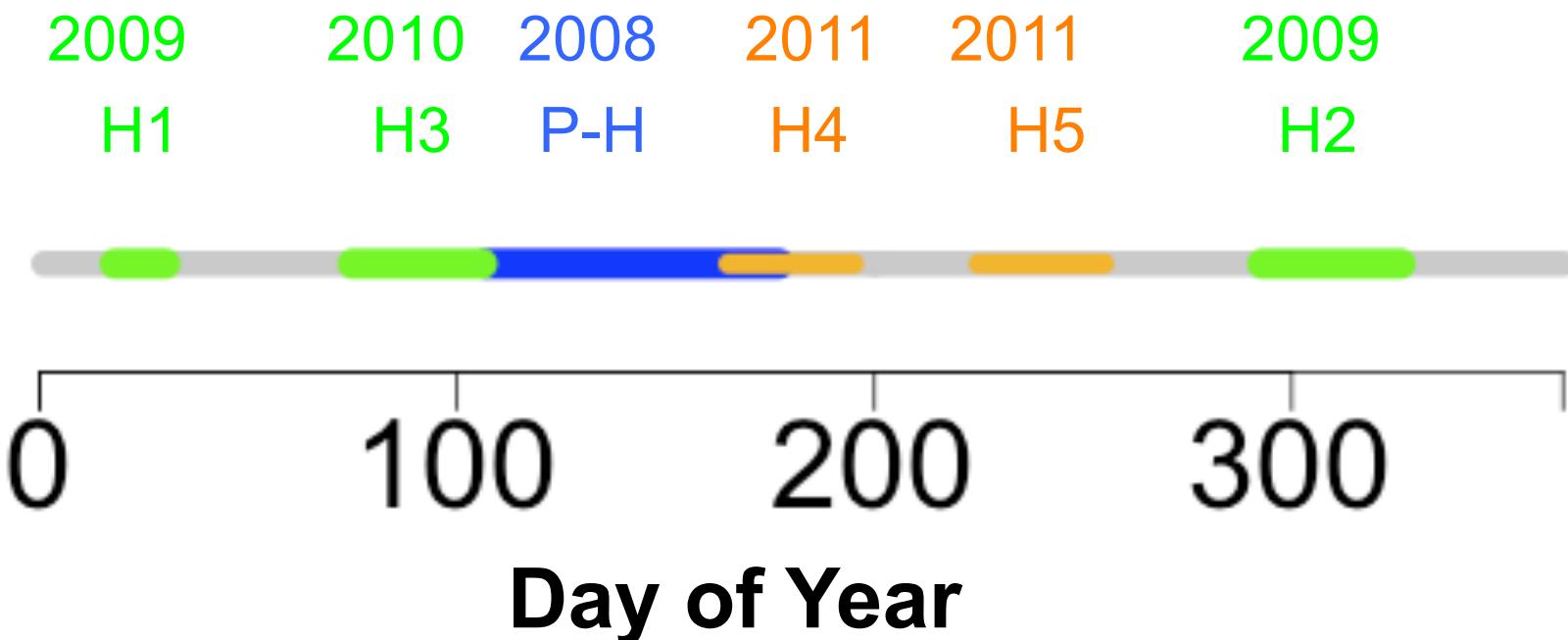
HIPPO_1 Jan 2009



HIPPO_3 Apr 2010



HIPPO Statistics



To Date: *156 days of field program, 524 profiles*

HIPPO Sponsors

- National Science Foundation
- National Oceanic and Atmospheric Administration
- G-V "HIAPER": National Center for Atmospheric Research

HIPPO scenes

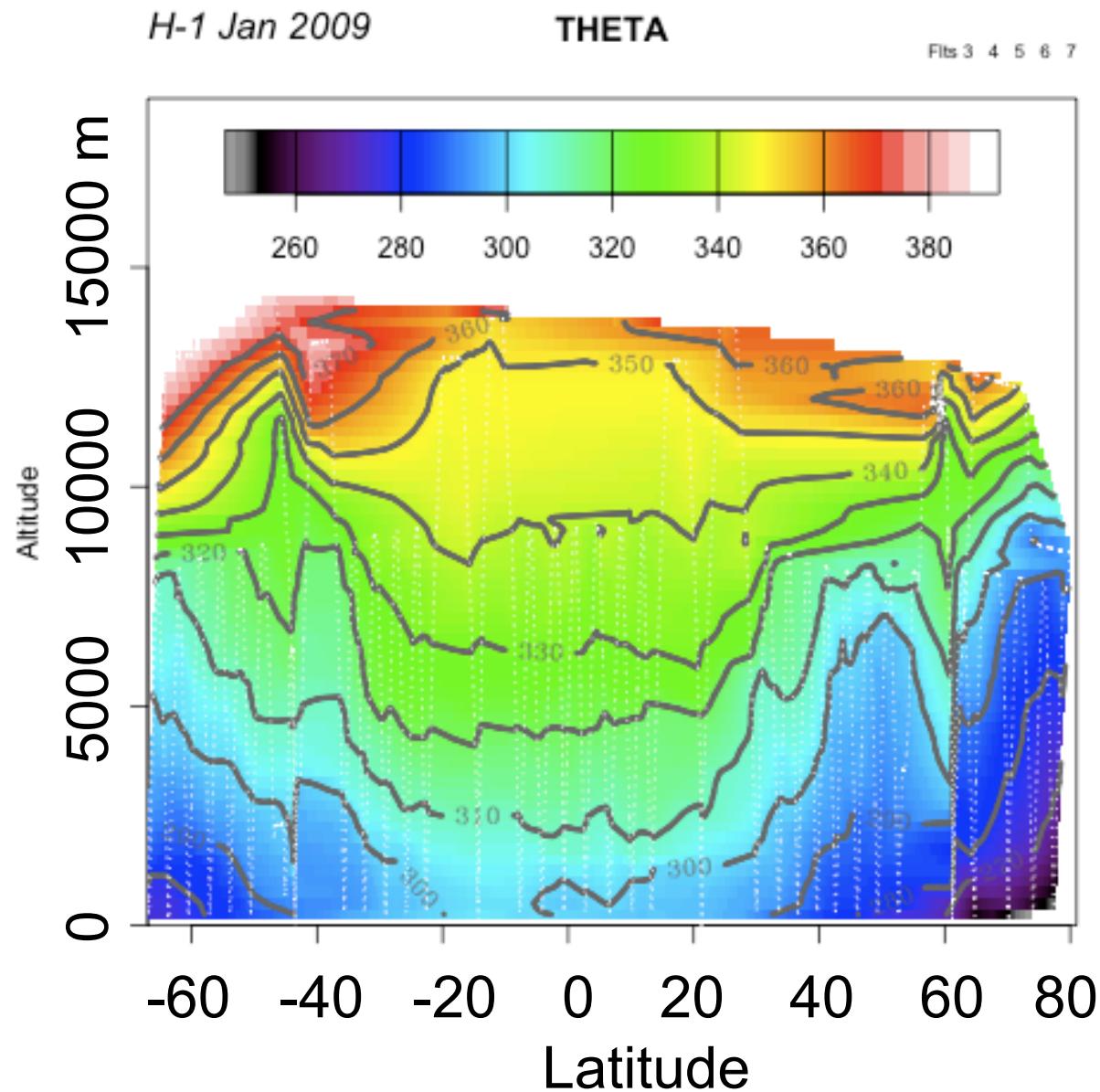
Shadow of the Earth visualized by ice crystals over Alaska.

Pago Pago, Samoa

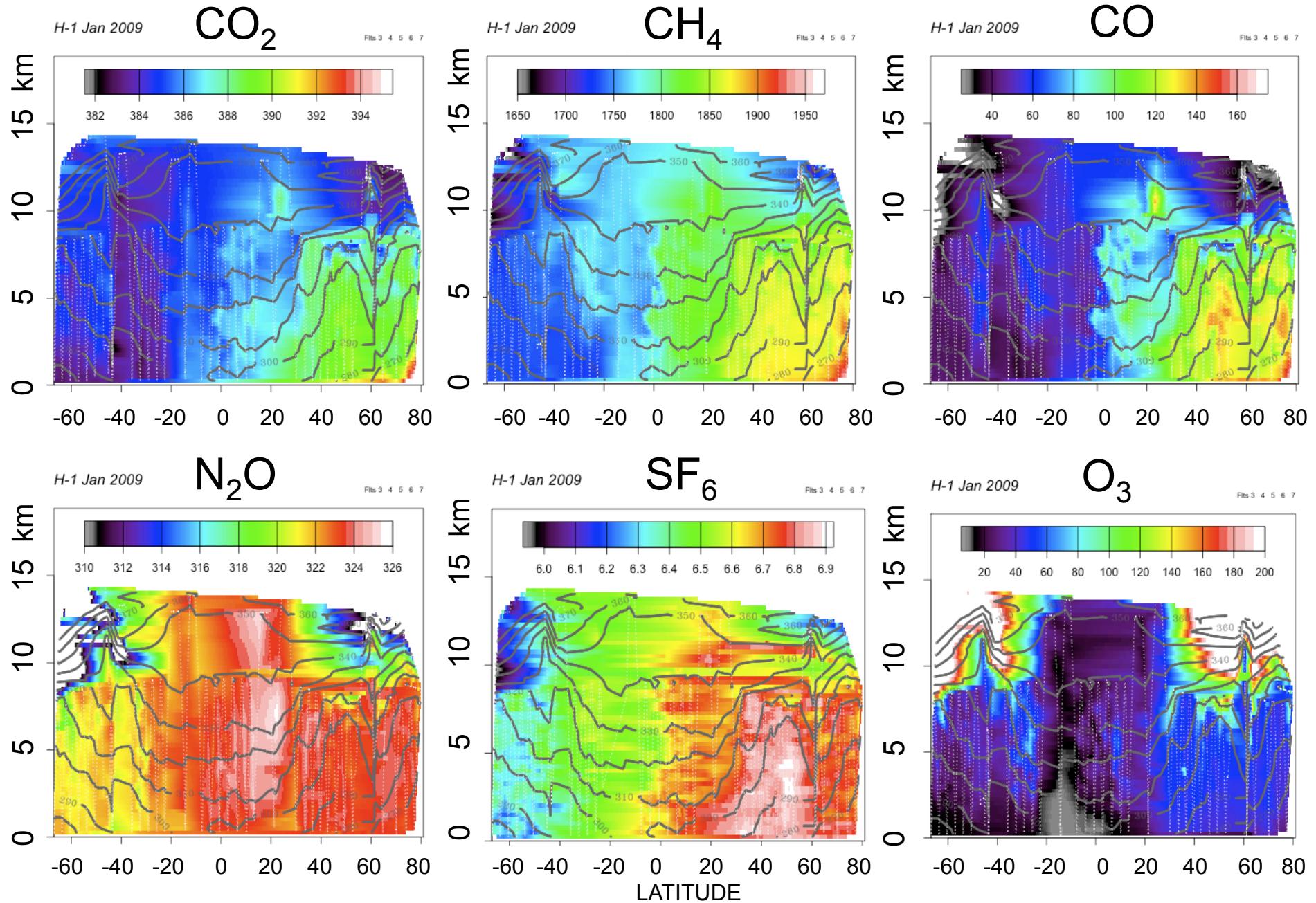


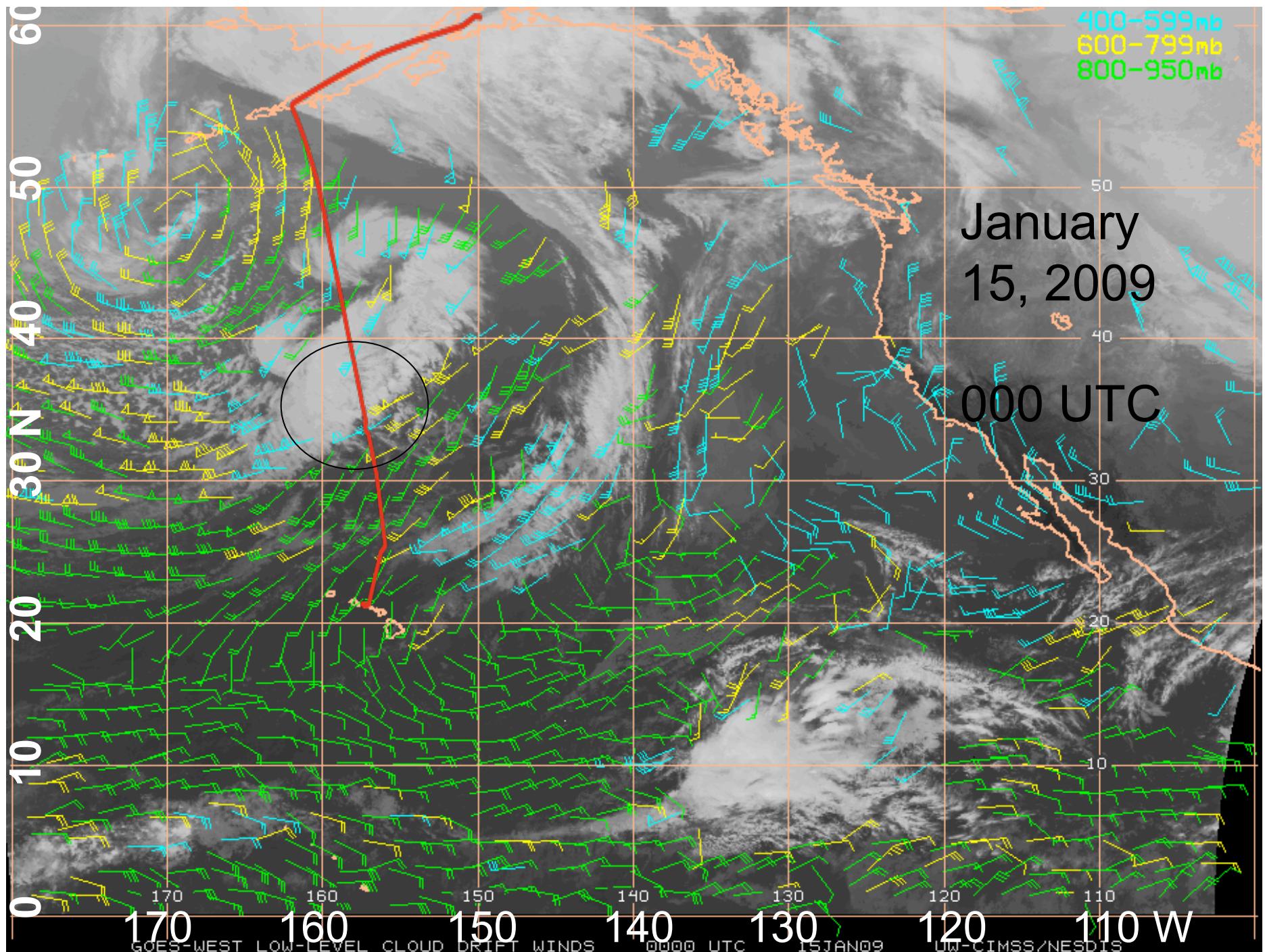
ITCZ

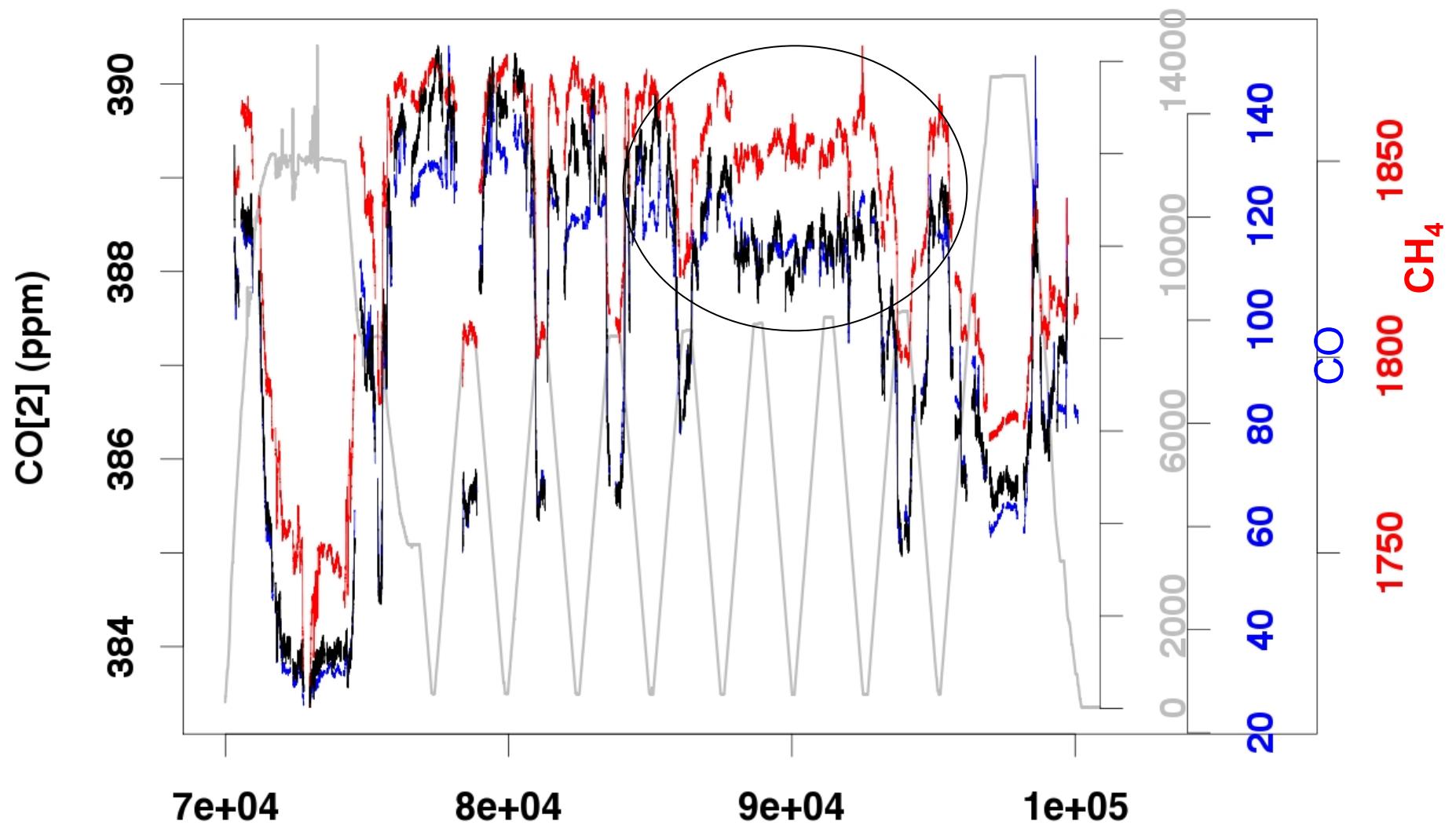
HIPPO-1 Atmospheric Structure (Pot'l T K):
January, 2009, Mid-Pacific (Dateline) Cross section



HIPPO sections, January 2009





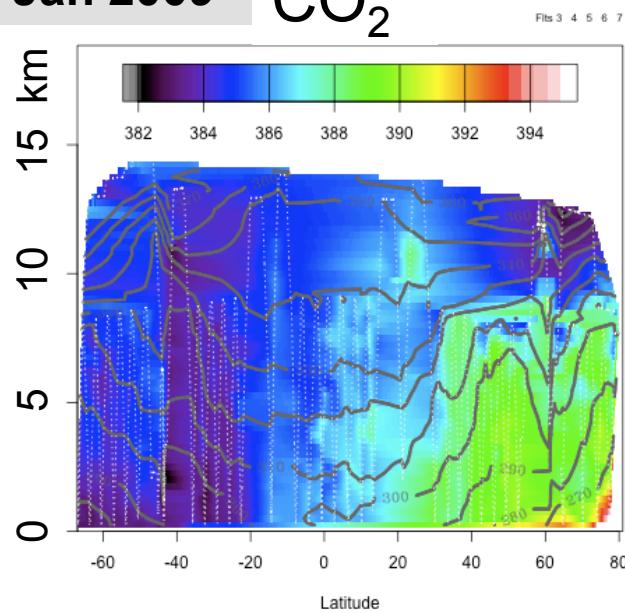


UTC HIPPO_1 Flight 4 Anchorage -> Hawaii

14 January 2009

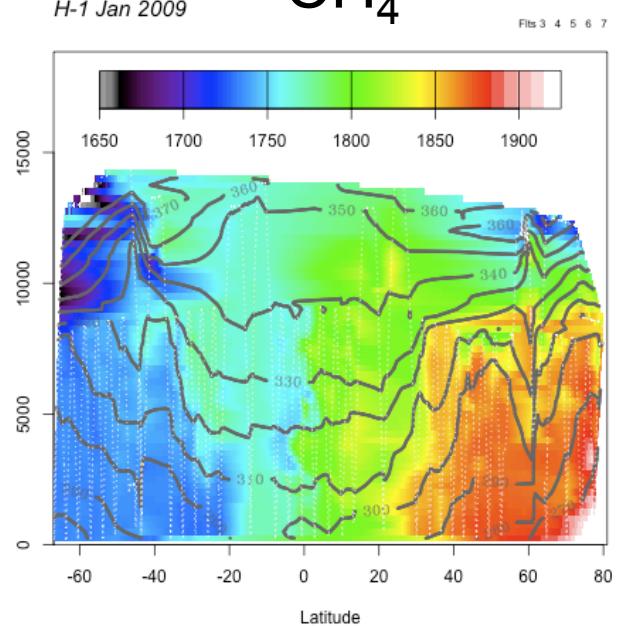
Jan 2009

CO₂



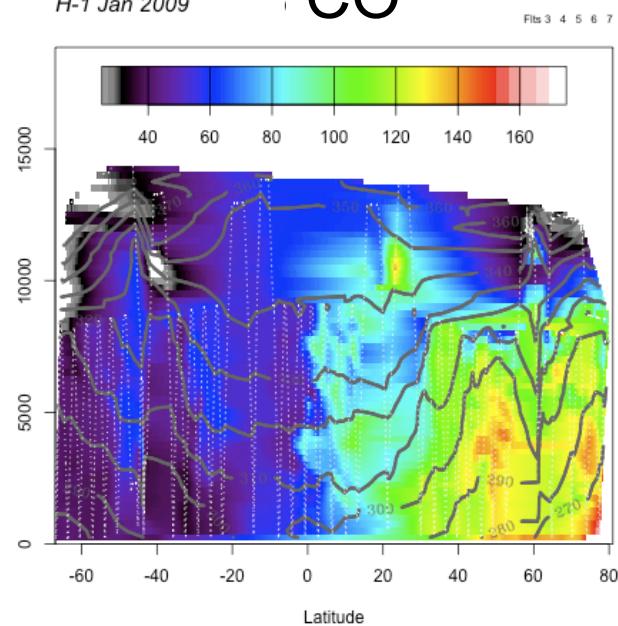
CH₄

H-1 Jan 2009



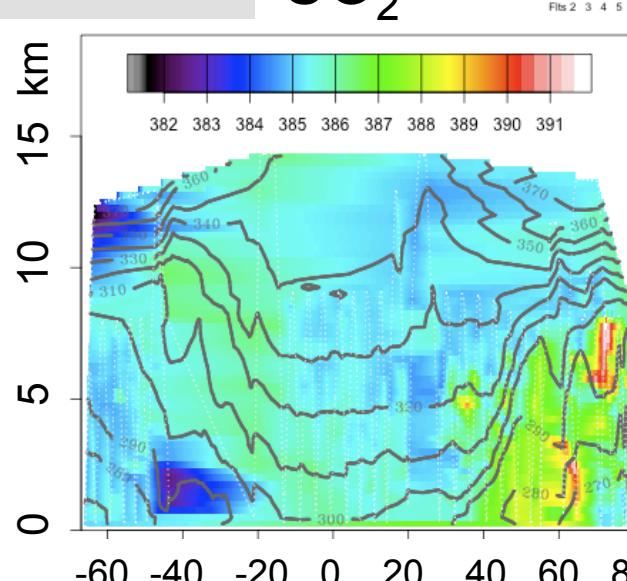
CO

H-1 Jan 2009



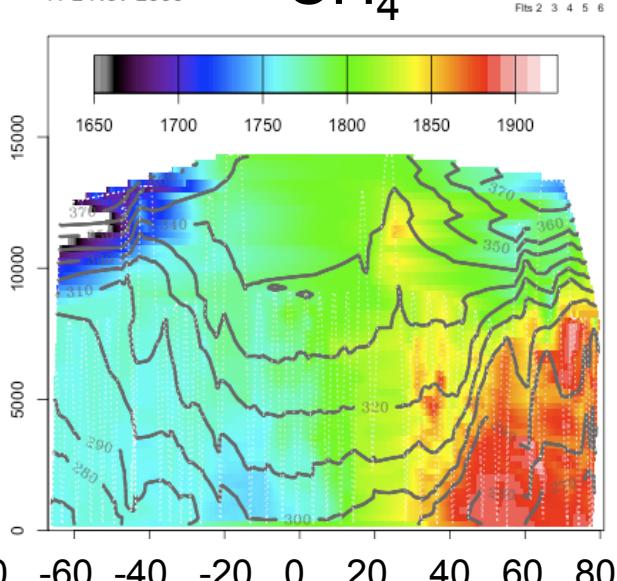
Nov 2009

CO₂



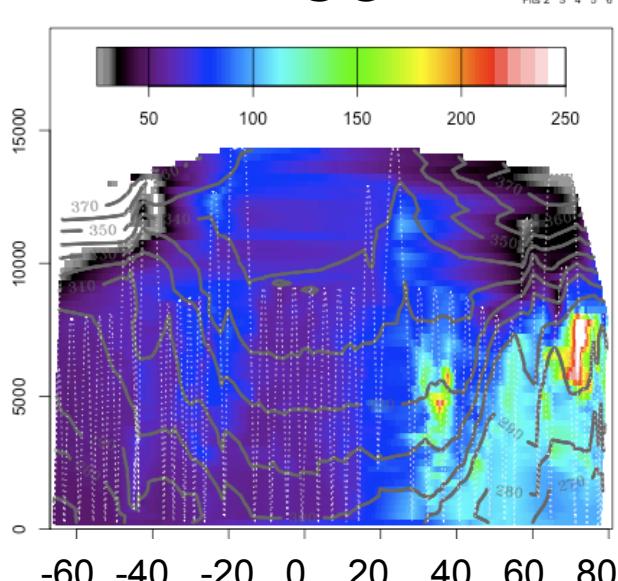
CH₄

H-2 Nov 2009



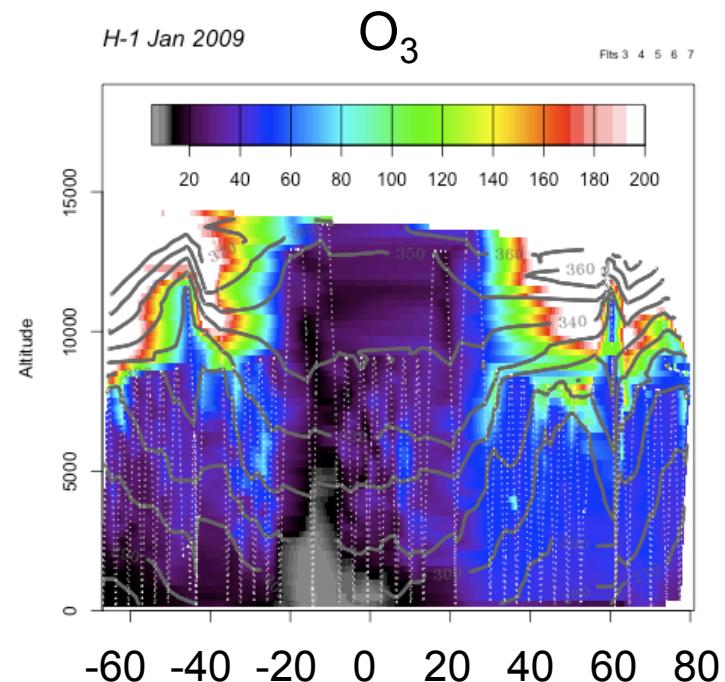
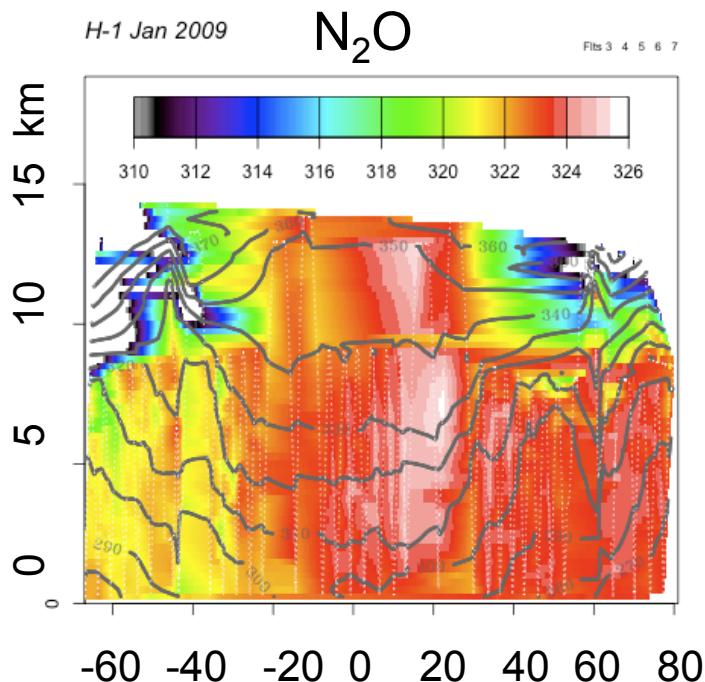
CO

H-2 Nov 2009

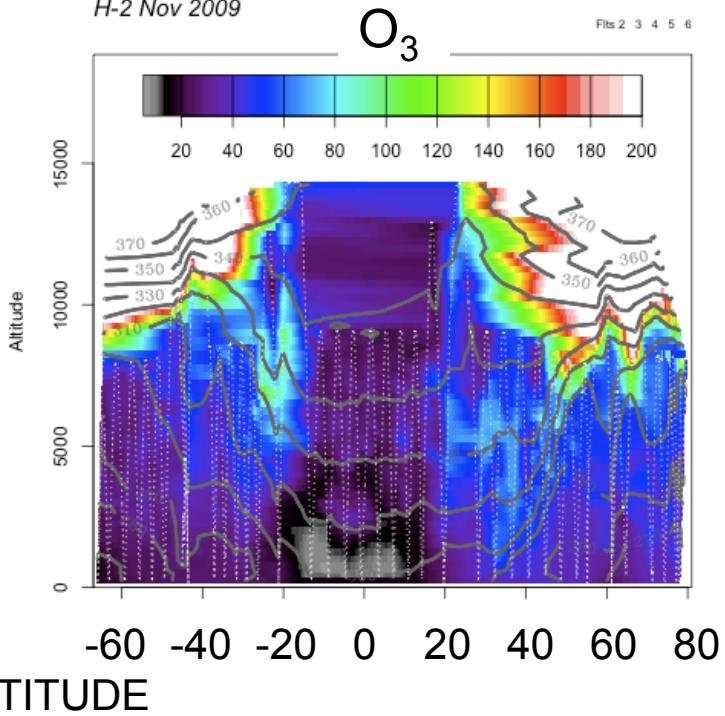
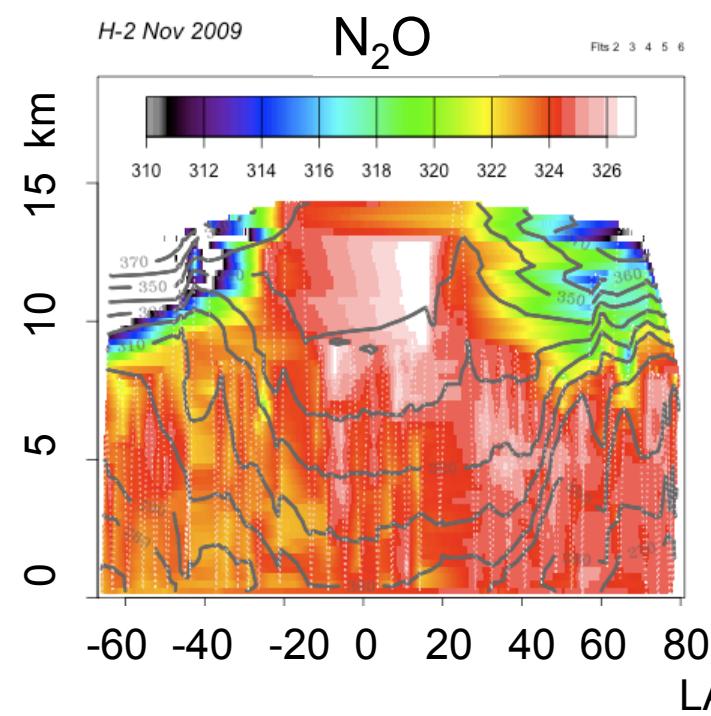


LATITUDE

**January
2009**

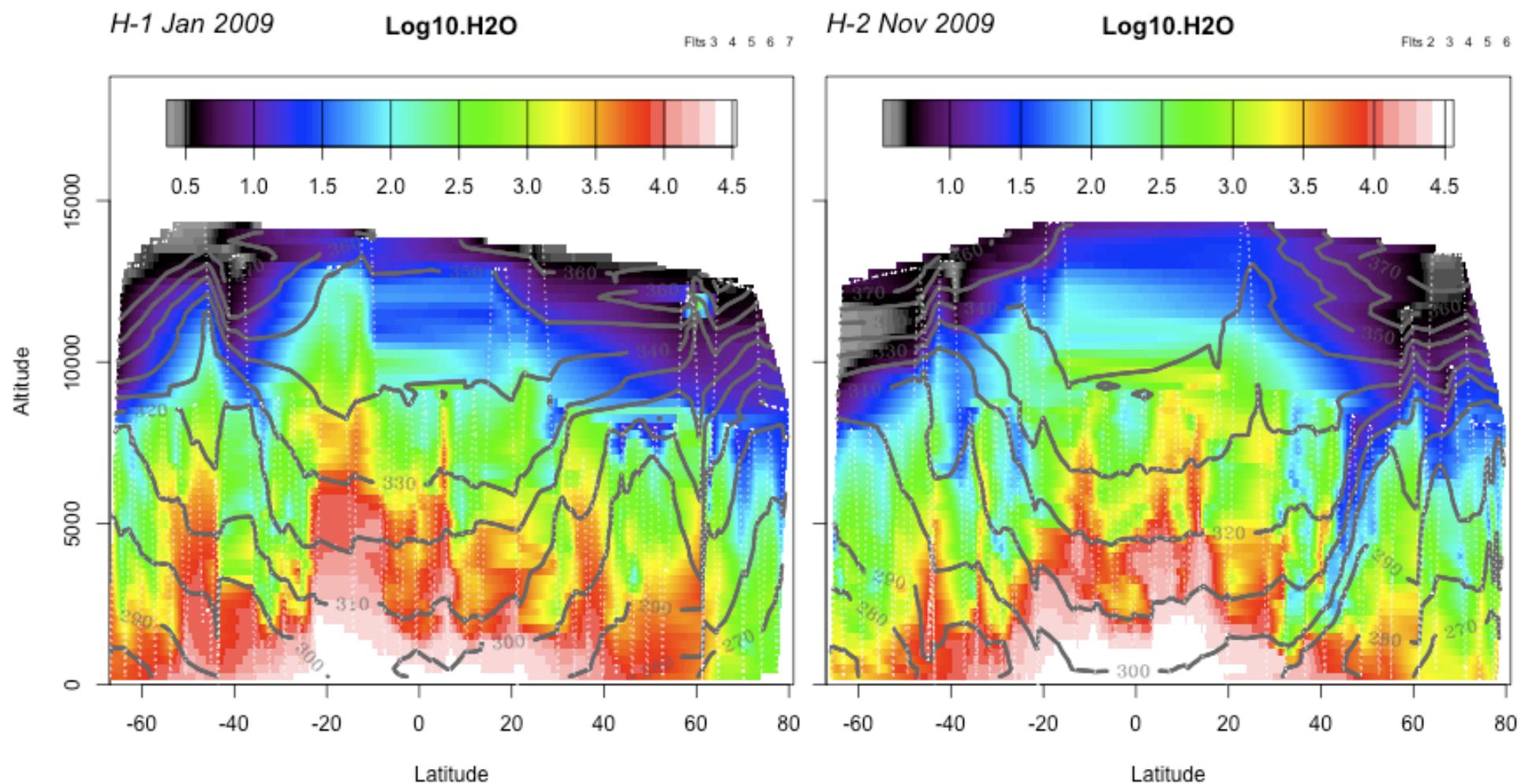


**November
2009**

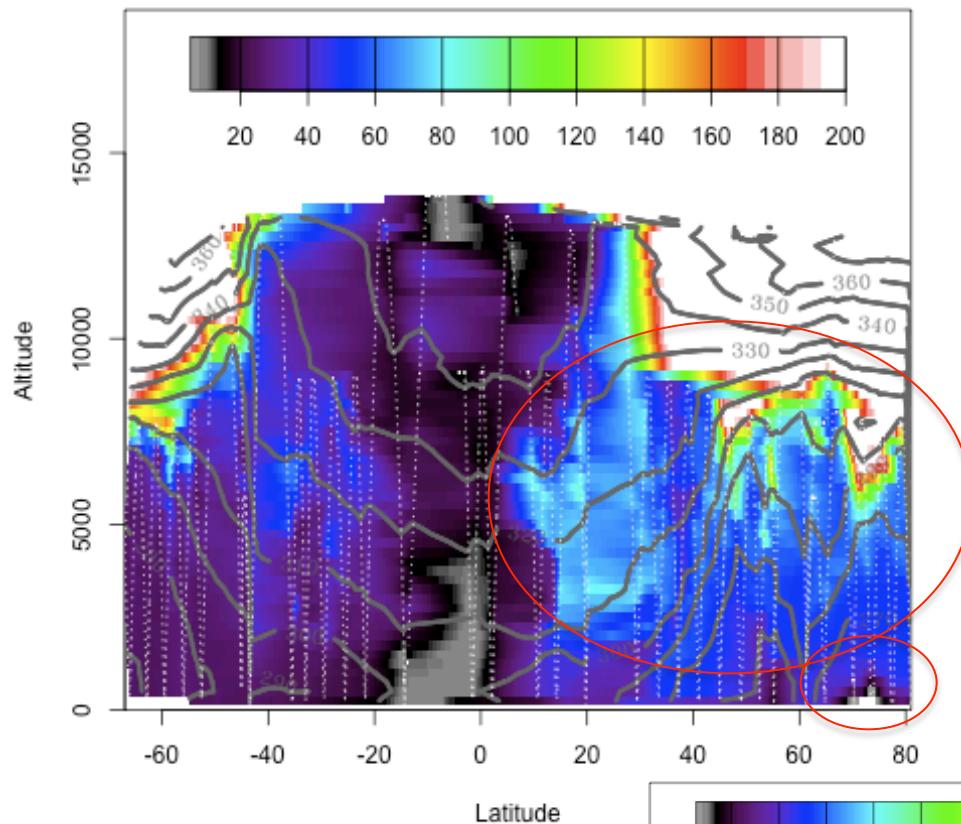


LATITUDE

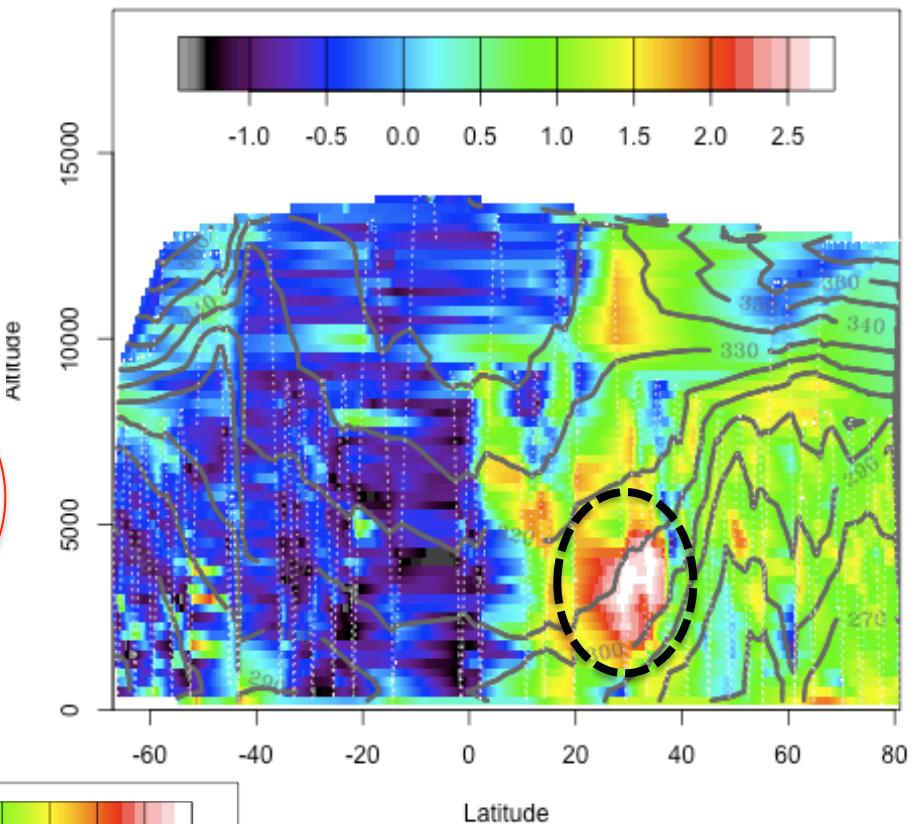
January – November Water Vapor comparison



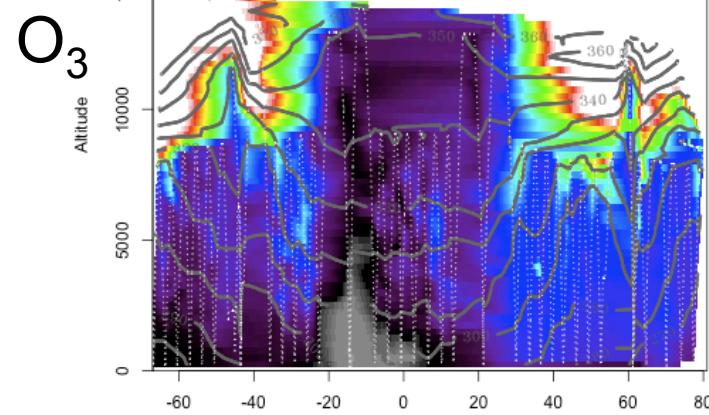
H-3 Mar-Apr 2010 O_3



BC Log10.BC

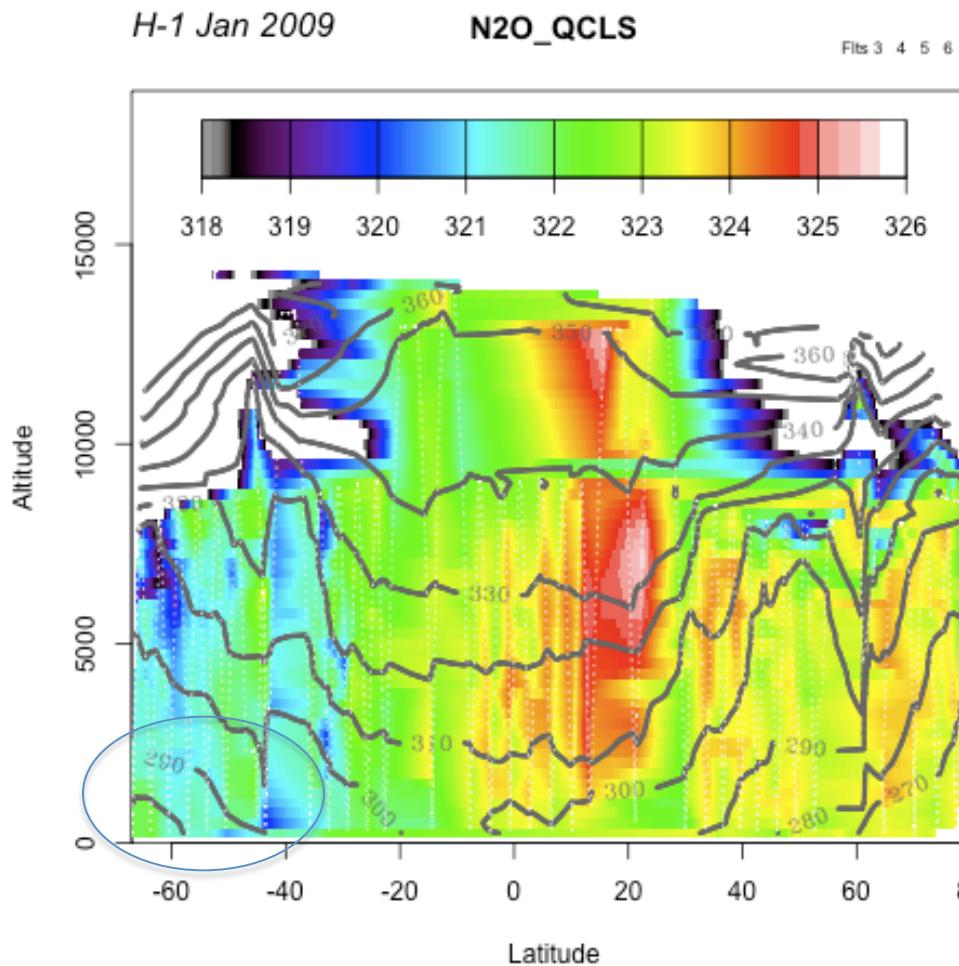


H-1 Jan 2009

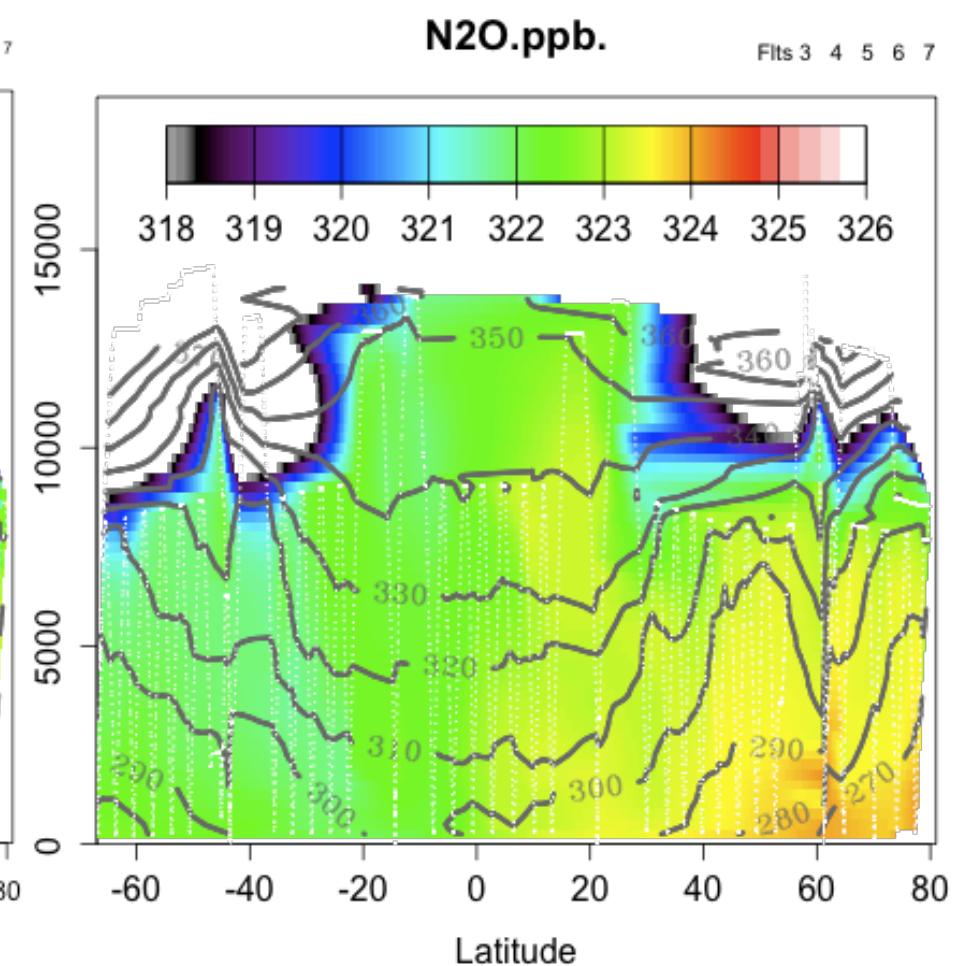


HIPPO Nitrous Oxide (N_2O)

Observed vs Model (ACTM)



HIPPO_1 Jan 2009



Prabir Patra, Kentaro Ishijima

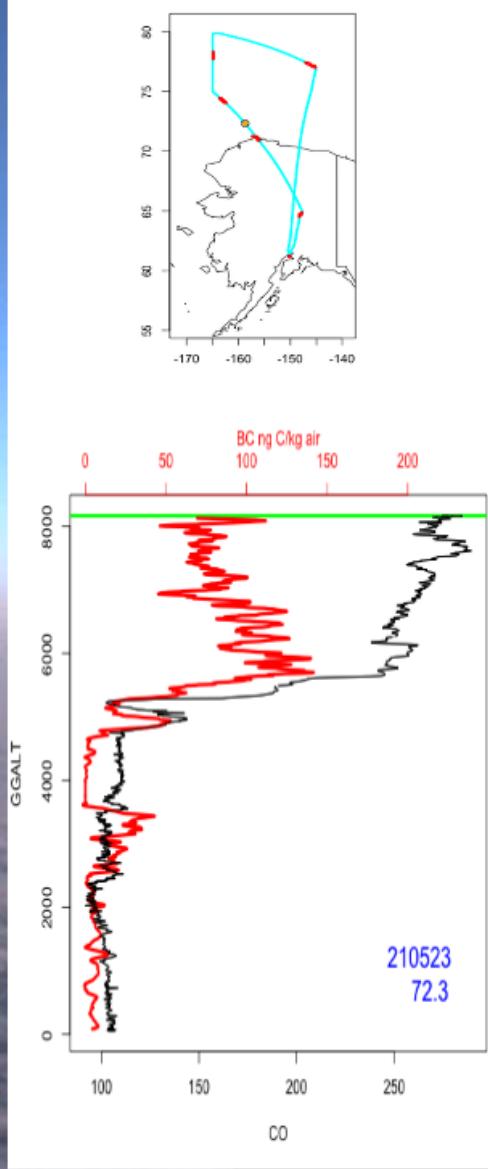
HIPPO Arctic Pollution

Pollution in the upper troposphere of the Arctic

...a fall/winter transition phenomenon

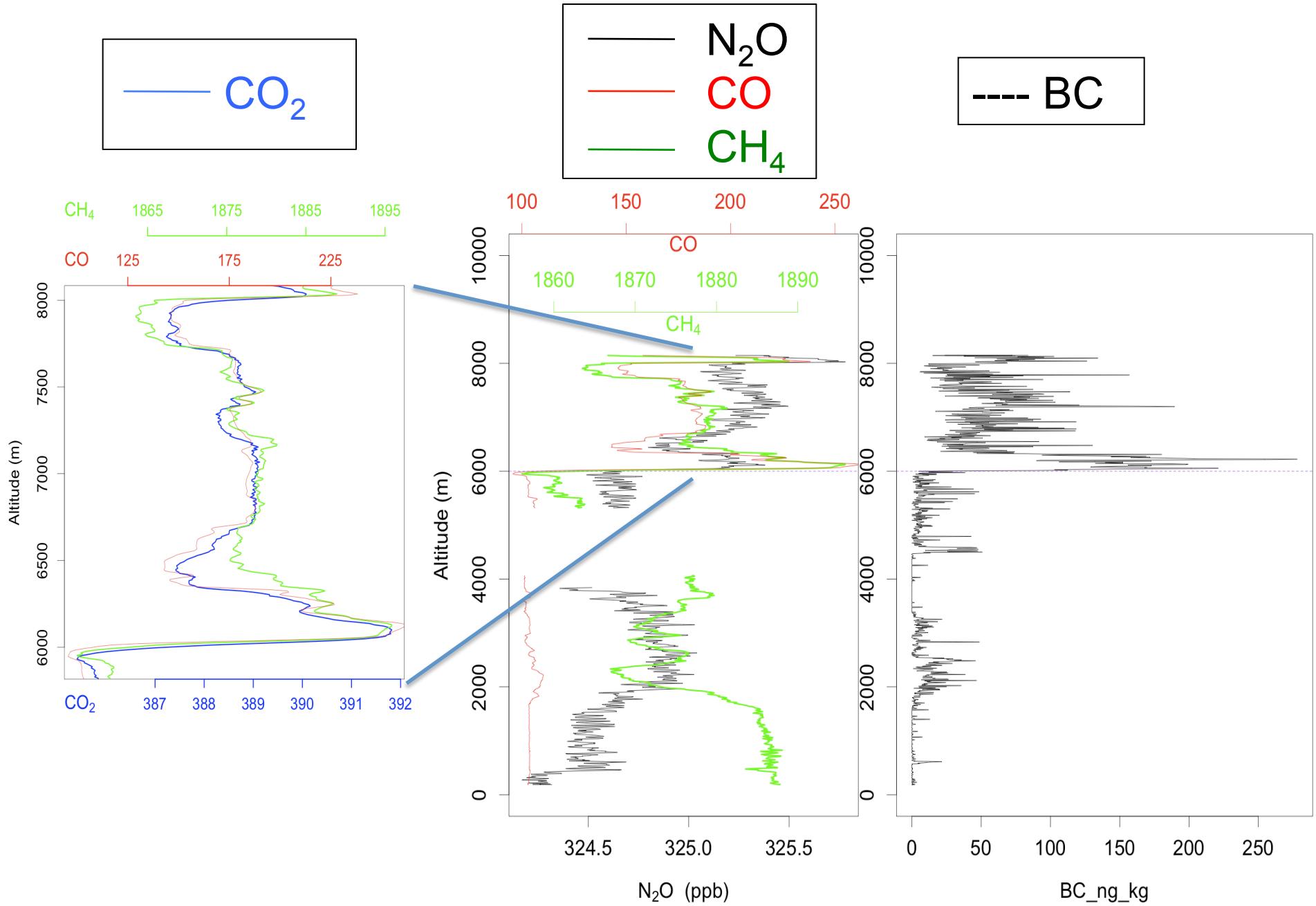


091102-210522





80 N 2009 11 02 *Photo E. Kort*



What we learn from this:

ATTREX science would be enormously enhanced by a companion mission of the GV *or the DC-8*...because it really matters what is going on below Global Hawk flight levels.

We should lavish some attention on jet stream transports, strong-CAPE convection over North America, and the SPCZ.

What we have yet to learn:

What is the global picture ?